

P. H. & F. M. Roots Co.
Connersville
Fayette County
Indiana

HISTORIC AMERICAN ENGINEERING RECORD

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Historic American Engineering Record
National Park Service
Department of the Interior
Washington, D. C. 20240

HISTORIC AMERICAN ENGINEERING RECORD

P.H. & F.M. Roots Company

HAER IN-3

Location:	East side of Eastern Avenue, opposite 1st Street. UTM: 16.659580.4388850 Connersville, Fayette County, Indiana.
Present Owner:	Connersville Properties, Inc. (Harry Alpert)
Significance:	The buildings of the P.H. and F.M. Roots Company, while typical of 19th century industrial structures, are significant not for their architecture but for their association with Philander H. and Francis H. Roots and their product. Roots blowers were the first commercially successful positive principle rotary blowers manufactured in the United States, and the Roots Blower Company was Connersville's first major industry.
Historian:	Robert Brueggmann

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The Roots Brothers

The brothers Francis Marion and Philander H. Roots were the sons of Alanson Roots. In 1846 Alanson Roots acquired rights to water power on the Whitewater Canal in Connersville and moved there from Oxford, Ohio. He set up a woolen mill in the city on the canal between 6th and 7th Streets. A good deal of information is known about F.M. Roots because his son-in-law, Edwin F. Schively, wrote his biography in 1893.²

The Invention

The Roots brothers apparently discovered the principle of their blower in 1859. The old over-shot water wheel at their woolen factory required attention and they experimented with new types of wheels. One device consisted of two lobed wood wheels which revolved in opposite directions when the water was forced past them. However, the wood swelled because of the moisture and the device was not successful as a water wheel.³ Two patents were, nevertheless, secured for water wheels following this principle.⁴ While testing the machine, the brothers did notice that it seemed to be an effective mover of air.⁵ The device that they eventually worked out was patented in 1860. It was the basis for almost all of the later Roots rotary positive blowers.⁶

The blower which was patented in 1860 works on a very simple principle. Two impellers, marked A and B on the diagram, move in opposite directions in a close-fitting housing. The shape of each impeller with its two lobes and two depressions between them is calculated so that the impellers are always in very close contact with each other as well as with the outside casing. This prevents any air leakage.

In operation, air entering the blower at D is literally pushed by one of the impeller lobes upward and toward the perimeter of the casing and then forced out the discharge outlet at E. It is apparent that this action is exactly the reverse of the way a water wheel would operate. In this case the water rushing through would force the impellers to move, turning shafts which would power machinery.

Positive Principle Rotary Blowers

A blower is a device for moving gases. The word is usually applied to machines that produce only moderate compression. Machines that operate at lower pressures are generally called fans. For example, in the common axial-flow window fan very little pressure can be built up on the discharge side because the air can slip back through the blades. Devices which produce much higher pressures are normally called compressors.

"Positive Principle" means that the air is forced forward by positive displacement. It is literally pushed out of the discharge outlet by the impellers. They operate so that the air can never leak back. Roots blowers are called rotary because the two impellers revolve. This distinguishes them from other types of blowers which use the reciprocating action of pistons drawing in and expelling air by moving in a linear fashion.

Corporate History

The Roots brothers received their first significant orders in 1864.⁷ In 1887 they were able to incorporate as the P.H. and F.M. Roots Co. with a capital stock of \$100,000.⁸ The firm operated under this name until 1929. In that year the Roots concern was bought by an Ohio syndicate under the control of the Stacey Engineering Company, which became the International Stacey Corporation in 1931. The old Roots operation was merged with the Connersville Blower Company⁹ in 1934 to form the Roots-Connersville Division. The division became part of Dresser Industries in 1944.¹⁰ The original Roots Blower buildings continued to operate until the end of World War II. They were briefly used again in the early 1950's and then sold in 1952.¹¹ The buildings are currently being used for grain storage.

Building History

The Roots complex today consists of a number of buildings built over a period of years. The somewhat haphazard over-all design is a result of a gradual accumulation of new construction and alterations. The essential core of the building, however, is largely a product of the final quarter of the nineteenth century. There may be some remnants of buildings constructed in the 1840's or 50's and the last major units were completed in the early 20th century, but generally the factory represents a typical large industrial complex of the late 19th century.

Dates for the major buildings are not precisely known. Most of the information available has been pieced together from engraved views and photographs. The important documents in this respect are listed below with the name by which they will be referred to in the descriptions:

1. 1856 Map¹²
2. 1880 Scientific American view¹³
3. 1888 map and view¹⁴
4. 1899 Indianian article view¹⁵
5. Early 20th century letterhead view¹⁶
6. 1906 Schwarz view and photographs¹⁷
7. 1926 Indianapolis Star view¹⁸

Using this information the major parts of the Roots complex can be dated approximately as follows (letters refer to the diagram):

- A-1 Completed before 1888. The north facade and north part of the east wall before 1880 and perhaps as early as the 1840's or 1850's.¹⁹
- A-2 Before 1880²⁰
- A-3 1890's²¹
- A-4 Dates uncertain. Several construction phases completed before 1900.²²
- B Before 1888²³
- C Before 1888²⁴
- D Before 1906; probably sometime between 1888-1906²⁵
- E Sometime between 1900 and 1926²⁶

There are several documents which give visual information about the uses of these buildings at various times. These include:

1. The 1880 Scientific American interior views
2. The 1899 Indianian map labels
3. The 1926 Indianapolis Star view labels

In the 1880 Scientific American article there are views of a boring

mill and planing room, a lathe room, a setting-up room, and a foundry. The foundry is probably the low building with a monitor roof in the center of the 1880 Scientific American exterior view, since a monitor roof seen on the exterior view is also visible on the interior view. Otherwise the location of the other interior spaces cannot be determined with any certainty.

In 1899 the section labeled A-1 was used as a machine shop, A-3 as the erecting shop, B as the office and C as the foundry. By 1906 the new building, D became the foundry. In 1926 A-1 remained a machine shop, B remained the office, and A-3 and C as well as the new complex D were used as machine and erecting shops. The foundry was moved to E.

Earlier Rotary Positive Devices

The idea of the rotary positive machine was not a new one. Many earlier examples are known, the most famous being the Pappenheim Engine, perhaps dating to the 17th century. The German engineer Franz Reuleaux described this engine as well as a number of other early examples in his Kinematics of Machinery. These devices all used a similar principle, that of two opposite rotating wheels geared together by teeth or lobes.²⁷ They were used as pumps and ventilators among other purposes.

Reuleaux also states that shortly before the Roots invention almost identical blowing devices were constructed in England. He cites one made by George Jones of Birmingham in 1859 and an earlier one of 1858.²⁸ It is not impossible that the Roots simply copied recent British work and secured an American patent for it. However, as far as it is known, there would have been no way for the Roots to know about the British work, and the examples cited by Reuleaux preceeded their work only by a year or two at any rate. Thus, although the idea was an old one, the Roots should be credited with perfecting the design and first putting it into operation on a large scale.

This is the conclusion of the London-published Engineer of 1867 reporting on the exhibit of the Roots company at the Paris exhibition: "Mr. Roots has the merit of having brought the machine independently to such a state of perfection as to render it superior in many respects to the ordinary fan, and to make it an aspiring competition with the blowing cylinder."²⁹

Uses of the Roots Rotary Blower

The first major use of the Roots blowers was in cupola furnaces. The first two experimental machines were tested in foundries and large numbers of blowers were manufactured for this purpose. A large blower for the West Cumberland Hematite Iron Works in Workington, England, was described in 1872.³⁰ At the Philadelphia Centennial, Roots blowers were praised by the Scientific American Supplement as efficient and economical devices for use in foundries:

In a force-blast blower there are two great benefits: economy of power and certainty of result. The blowers

exhibited by the Messrs. P.H. and F.M. Roots, of Connersville, Indiana, seem to come up to these requirements.

In reference to economy of power, they, operating by a regular displacement of air, which is forced forward in constant quantity at each revolution use all the power applied either in driving the machine or forcing the air forward. Friction is slight. The internal parts do not come in contact during running, simply approaching each other as close as possible without an actual contact; this renders the blower practically air-tight. The power applied is absorbed but slightly in running, and is therefore almost entirely applied to the work of forcing the air forward. Results are as far as possible certain with these blowers...In securing the best possible results, the proportional amounts of iron to be melted, fuel used, and of air supplied in a given time, should be fixed and unvarying. As these blowers measure and force forward a definite quantity of air at each revolution, constancy of melting conditions are secured."

In 1917 Industrial Management magazine reported that rotary blowers were still largely used for cupola work. It also stated that they were most economical for pressures between 1/2 pound per square foot and 8 or 9 pounds per square foot.

Another major use of the blowers was in mine ventilation. This was a relatively new field³² and Roots blowers constituted some of the largest installations in the 19th century. Already by 1870 several Roots blowers were in use in mines of the Comstock lode.³³ Two of the largest Roots blowers ever made were installed at the Chilton Colliery near Ferryhill, England in 1877. The impellers each had a diameter of 25 feet and were 13 feet wide. The maximum capacity of the two machines was 200,000 cubic feet per minute. The ventilator was housed in an engine house with a perforated roof. The Engineer of London, reporting on the results of tests run on various ventilators, concluded that the Roots machines were the most efficient that had been installed in mines. The other ventilators compared were those of Cooke, Waddles, Rammell, Leeds, and Guibal.³⁴

Of the many uses to which the blowers were put, certainly the most spectacular was in the underground subway constructed by Alfred Beach in 1867 under Broadway in New York City. This "aeolar" had an iron shell 21 1/2 feet high and impellers 16 feet long. At 60 revolutions per minute it produced 100,000 cubic feet of air a minute. Costing \$20,000, the machine was transported on five large platform cars. The "Western Tornado", as it was called, was pictured in a contemporary pamphlet with the figure of a man inside to show the huge scale. The "aeolar" provided the power for a 22 seat passenger car which ran on tracks from Murray to Warren streets. The car was literally blown to one end and then sucked back by the action of the machine.³⁵ Other uses were in pneumatic tubes, aeration and agitation, supercharging and scavenging on diesel engines, and in vacuum processes.

Further Patents

Most of the patents which the Roots brothers took out after 1860 were modifications of their first scheme. In almost every case these alterations were intended to allow a closer fit, less friction in operation and cheaper means of construction.

The case was modified in a series of patents. Originally sheet metal bent to the proper shape was used. In 1864 the Roots patented a shell made of two pieces of cast iron joined together by metal plates.³⁶ In 1868 they further modified the design by placing packing strips in the case which formed the contact surface for the impellers. This was done to cut down on friction and to allow the cast iron case to be made rough since the impellers were no longer in contact with it. This reduced the costs of boring and polishing.³⁷ Later in the same year a patent was obtained specifying soft metal or plaster of Paris for this purpose.³⁸

The shape of the impellers was also modified several times. In 1886, the Roots patented a design for impellers which were constructed of a metal core adjusted to the desired shape by wood strips. This was more economically constructed than solid iron impellers and allowed them to be renewed without entirely reconstructing the entire impeller.³⁹ In the same year, the Roots also modified slightly the shape of the impellers creating the Figure-8 shape which became very common thereafter.⁴⁰ The design of the impellers was subsequently modified in 1868, 1881, and 1882.⁴¹

Production

Between 1859, when the blower principle was discovered, and 1864, a half-dozen blowers were produced.⁴² These were made at the woolen mill and were largely experimental. The first two large blowers were placed at foundries, one in Cincinnati, the other in Covington, Kentucky. These proved extremely successful,⁴³ and production really began on a larger scale in 1864 with orders for fifteen blowers.⁴⁴

In this year the Roots bought the Gephart stove foundry and almost immediately started to make additions.⁴⁵ By 1874 the works had expanded so that they employed over 100 men.⁴⁶ In 1915 there were about 225 employees.⁴⁷ Already by 1880 the blowers had been exhibited in three international expositions and had attracted attention world-wide.⁴⁸ A catalogue of that year which has been preserved in the company files states that 3,000 blowers were in use at that time in England alone with as many more on the Continent, in addition to those in use in this country. The catalogue gives a description and price list of the company's principal products.⁴⁹

Fairs

The popularity of the Roots invention was in great measure due to the exhibits which the company mounted at World exhibitions, particularly those at Paris, Vienna and Philadelphia. At each fair the blowers won prizes and attracted attention.⁵⁰

At Paris in 1867 the machine exhibited had the figure-8 shape which had been patented in 1866,⁵¹ but the impellers were of solid wood rather than iron or a combination of iron and wood which the Roots normally used.⁵² It received very favorable comment both in this country and abroad.⁵³

At the Centennial Exposition in Philadelphia the company exhibited

two machines with impellers of different shapes. The verdict of the technical press was again favorable.⁵⁴ The engineers were not the only ones who found the blowers interesting. An illustration in Frank Norton's Historical Register of the Centennial Exposition shows a machine, perhaps constructed by the Roots, blowing the hats off of the heads of surprised and amused visitors passing by.⁵⁵

Notes

- 1 The trace of the canal is still visible in Connersville, A depression is still apparent in some cases and the Penn Central Railroad track runs along the former tow path.
- 2 Edwin R. Schively, Biographical Memoir of Francis Marion Roots, Philadelphia: 1893.
- 3 Schively, Biographical Memoirs.
- 4 These patents were Number 23,267, secured in March 15, 1859, and Number 27,239, secured in February 21, 1860.
- 5 There is an apocryphal story, pleasant even if untrue, that while the brothers were running the machine dry one of their hats was blown into the air demonstrating graphically the possibility of using the machine as a blower. "His chance remark, 'That's a better blower than a water motor' led to the establishment of a business that is known throughout the world, and has carried the name Connersville to the far places of the earth, and to every continent on the globe." Connersville News-Examiner, October 19, 1937, p. 6.
- 6 This was patent Number 30,157 secured September 25, 1860.
- 7 Schively, Biographical Memoir.
- 8 The Indianian, Vol. 3, No. 4. "Fayette County and Connersville, the Garden City of Indiana," p. 217.
- 9 This company was formed in 1893 when an engineer from the Roots works, John T. Wilkin, set up a rival company on the other side of town. Henry Blommel, "Indiana's Little Detroit," p. 2. "A Century of Service to Industry," pamphlet issued on the Roots-Connersville division centennial in 1954, p. 5.
- 10 "A Century of Service to Industry," p. 5.
- 11 Blommel, "Indiana's Little Detroit", p. 2.
- 12 Front endpaper, The Book of the 150th Year of Connersville, Indiana. This map shows a small industrial complex at the site labeled the Connersville Iron Foundry.
- 13 Scientific American, 1880, p. 127. The view shows a main two-story building facing the canal. Behind it are subsidiary structures.
- 14 Back endpaper, The Book of the 150th Year of Connersville, Indiana. The map, a birdseye view from the south, shows the factory but in a very unreliable way. Very accurate from all indications, however, is the small inset view included in the map margins. This shows two long parallel buildings which are still standing today. The one to the east, two stories high under a gable roof and crowned by a cupola is A-1. The building in the center is the office wing, B, and the building to the right is the monitor gabled building, labeled C.
- 15 The Indianian, 1889, Vol. 3, No. 4, p. 218. This view from the Southwest shows A-1, A-2, A-3, B and C. It appears to be a quite accurate representation.
- 16 Letterhead in the possession of Kenneth Mills, Connersville. This view is not reliable in details and has inflated the number of stories in the building. But it is valuable in that it is a rare view from the northeast.
- 17 J.F. Schwarz, Pen and Camera of the Pretty and Progressive City of Connersville, pp. 124, 125. The view of the entire works shows all the major buildings except E from the northwest. The photograph is taken from the southwest.

- 18 Indianapolis Star, June 13, 1926, p. 2, Gravure Section. This view shows the entire plant from the northwest with all the major buildings, the plant railroad, the canal, the power house and other features now gone.
- 19 The 1880 Scientific American view shows a two-story block surmounted by a cupola which occupies the same place as the current structure labeled A-1. This structure may be the original Gephart stove foundry which was founded about 1846. Blommel, "Indiana's Little Detroit," mimeographed, 1963. When this building was sold to the Roots in 1864 they may have preserved parts of this structure. In any case, the 1880 view building certainly was incorporated into the structure visible in the 1888 map view, since the facade fenestration is almost identical. Apparently the roof was raised, a new gable constructed, and the building lengthened several bays to the south. The north facade, east wall, roof and cupola of the building visible in the 1888 map view have apparently been maintained to the present day despite drastic alterations. It appears that when the large addition marked A-3 was constructed, the entire east wall of A-3 was removed. The beams were lengthened by bolting new wood to the east end extending them another 10 feet. The new lengthened beams rest on a set of wood posts. This alteration removed the support for the rafters on the east side of the original gable roof. This load was now carried on posts which rested on the lengthened wood beams at the point where they were bolted together. This makeshift arrangement did not prove satisfactory and the beams have broken in the north end of the building. They are currently supported by temporary posts sitting on the elevator assembly.
- 20 The section of the building marked A-2 is probably part of the structure in the center rear of the Scientific American view on p. 88. The brick work on this section is unlike that of any other part of the complex and there are definite breaks in masonry where it joins the rest of the building.
- 21 This large addition first appears in the 1899 Indianian views. Probably during construction of this section the east wall of A-1 was removed and the space opened to form a large, clear interior area extending the full length of the Building A.
- 22 This section of the building is very unclear. There are several breaks in masonry and very little documentary evidence with which to date the parts. Probably part of the east wall is older than the large A-3 addition.
- 23 This building was always used as an office. It was in existence by 1888. However, the two westernmost windows on the second floor and the cornice of the entire wing were added after 1926.
- 24 This building is first seen on the 1888 map view. It has been essentially unaltered on the exterior.
- 25 This structure first appears in the 1906 Schwarz view.
- 26 This complex first appears in the 1926 Indianapolis Star view.
- 27 Franz Reuleaux, Kinematics of Machinery, Trns. A.S.W. Kennedy.
- 28 Ibid.
- 29 Engineer, August 1867, p.146.
- 30 Engineering, Vol. 14, October 11, 1872, p. 250.
- 31 Scientific American Supplement, Vol. 2, December 16, 1876.
- 32 Charles Singer, E.J.Holmyard, et. al., eds, A History of Technology, Vol. 4, p. 93.

- 33 Rossiter W. Raymond, Statistics of Mines and Mining in the States and Territories West of the Rocky Mountains, Government Serial, Vol. 1424, p. 524.
- 34 E. Hamer Carbutt, "Roots' Mine Ventilator," Scientific American Supplement, No. 100, 1877, p. 1589. Reprinted from The Engineer, June 15, 1877, p. 413.
- 35 "Illustrated Description of the Broadway Pneumatic Underground Subway," New York, 1870.
- 36 Number 44,892 secured November 1, 1864.
- 37 Number 73,854 secured January 21, 1868.
- 38 Number 81,010 secured August 11, 1868.
- 39 Number 56,614 secured July 24, 1866.
40. Number 58,745 secured October 9, 1866.
- 41 Number 81,009 secured August 11, 1868; Number 247,691 secured September 27, 1881; Number 264,962, secured September 26, 1881.
- 42 Edwin F. Schively, Biographical Memoir of Francis Marion Roots. Schively apparently had the original account book from these years.
- 43 Scientific American, February 28, 1880, p. 130.
- 44 Schively, Biographical Memoir.
- 45 Scientific American, January 28, 1880, p. 130. For building history, see above.
- 46 Ibid.
- 47 The Book of the 150th Year of Connersville, Indiana.
- 48 See below.
- 49 "Illustrated Circular of Roots' New Iron Blower," January 1880.
- 50 "A Century of Service to Industry,": booklet published 1954 by the Roots-Connersville Division, p. 6.
- 51 See above.
- 52 See above.
- 53 For example, in the Engineer, August 1867, p. 146; also "U.S. Commissioners Reports to the Paris Universal Exposition," Vol. 3, p. 193.
- 54 U.S Commissioners Reports, Philadelphia International Exposition, p. 40-42. This report also explains the operation of a rival rotary positive blower built on a different principle. The Baker Blower manufactured by the Wilbraham Brothers of Philadelphia. See also the very favorable report on the blower for use in foundries quoted above.
- 55 Frank Norton, Historical Register of the Centennial Exposition of 1876, p. 235.